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Articulatory correlates of morpheme boundaries: preliminary evidence from intra- and inter-gestural timing in articulation of the English past tense

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Introduction

- In Articulatory Phonology [e.g. 2, 8], lexical representations are stored as gestures and coordination relations between them.
- If lexical items consist of individual morphemes, then the coordination between gestures across morpheme boundaries may involve additional stages of lexical access and/or gesture coordination; that is, **articulation may be gated at morpheme boundaries**.
- Past research investigating phonetic effects of morpheme boundaries have reported mixed results; articulatory studies of Korean CV sequences showed **greater variability** at morpheme boundaries [3,4]; an acoustic investigation of English reported longer **duration** [6], but just for fricative affixes and not stops represented by the past tense morpheme.
- In this study, we revisit the English past tense morpheme, focusing on **articulatory measures which may be obscured in the acoustics**.

Results

- **Duration:** **C1 plateau duration** (Figure 2) and **target-to-target duration** were longer in the bi-morphemic condition.
- **Variability**: The **target-to-onset interval** was the only interval to show an effect of morpheme boundary on variability, being more variable in the bi-morphemic condition than the mono-morphemic condition.
- Additional fixed factors, cluster type (/pt/ vs. /kt/), cluster type*morpheme boundary interaction, and wordhood*morpheme boundary interaction did not improve model fit.

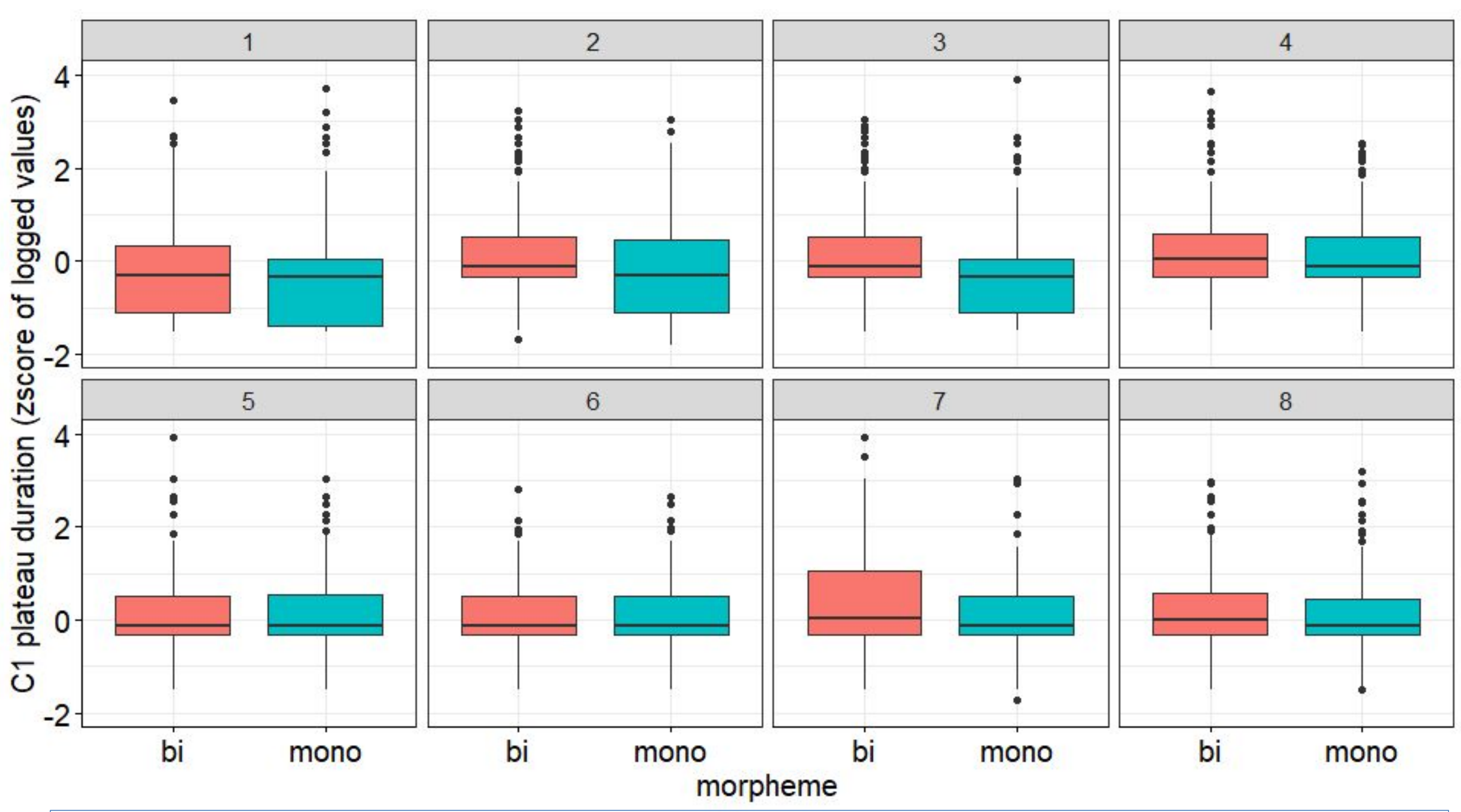

Figure 2: C1 Plateau Duration across Morpheme Boundary condition by Item

	Intervals	Duration	RSD
(1)	C1 gestural duration	NS	NS
(2)	C2 gestural duration	NS	NS
(3)	C1 plateau duration	*	NS
(4)	C2 plateau duration	NS	NS
(5)	onset to onset	NS	NS
(6)	target to onset	NS	*
(7)	target to target	**	NS
(8)	release to target	NS	NS
(9)	offset to onset	NS	NS

Table 2: Significance Results for 9 Gestural Intervals Measured

Methods

- *Participants:* 4 native speakers of American English (2F, uni students).
- *Materials (Table 1):* ≥ 23 repetitions; 32 target words (20 for /kt/ & 12 for /pt/); crossing two conditions: (1) morpheme boundary (e.g. *prepp-**ed*** vs. *accep**t***) and (2) wordhood (e.g. *pre**pp-ed*** vs. *ze**pp-ed***).
- *Articulography* data: collected using NDI Wave Speech Production system. Sensors were tracked on the tongue tip, blade, dorsum, jaw, lower and upper lips, along with reference sensors on the nasion and left/right mastoids, used to correct for head movements (Figure 1).
- Lip aperture 'LA' (for /pt/) or tongue dorsum 'TD' (for /kt/) gesture as C1 and the tongue tip 'TT' gesture as C2.
- Mview [7]: *findgest* used to parse 4 gestural landmarks: ONSET, TARGET, RELEASE, OFFSET (Fig 1). These landmarks then used to delimit 9 intervals: 4 intra-gestural, 5 inter-gestural (Table 2).

pair	Cluster	Boundary *(Bimorphemic)*		No Boundary *(Monomorphemic)*	
	Carrier Phrase	*Anita ___hearts*		*A need to___hearts*	
	Wordhood →	Real	Nonce	Real	Nonce
1	pt	prepped	zepped	accept	atept
2	pt	topped	nopped	adopt	anopt
3	pt	tapped	adapped	adapt	atapt
4	kt	checked	shecked	inject	inshect
5	kt	pecked	crecked	erect	enrect
6	kt	tracked	skracked	attract	enract
7	kt	wrecked	tecked	inspect	instect
8	kt	ducked	jucked	conduct	combuct

Table 1: Stimuli Set

- We fit linear mixed effects models [1] using *R* [5] to nine intervals, assessing the effect of morpheme boundary on interval **duration** and interval **variability** (RSD).
- Significance was determined by comparison of nested models via likelihood ratio tests.
- The baseline model consisted of segment count and wordhood as fixed factors, and by-speaker and by-word random intercepts.

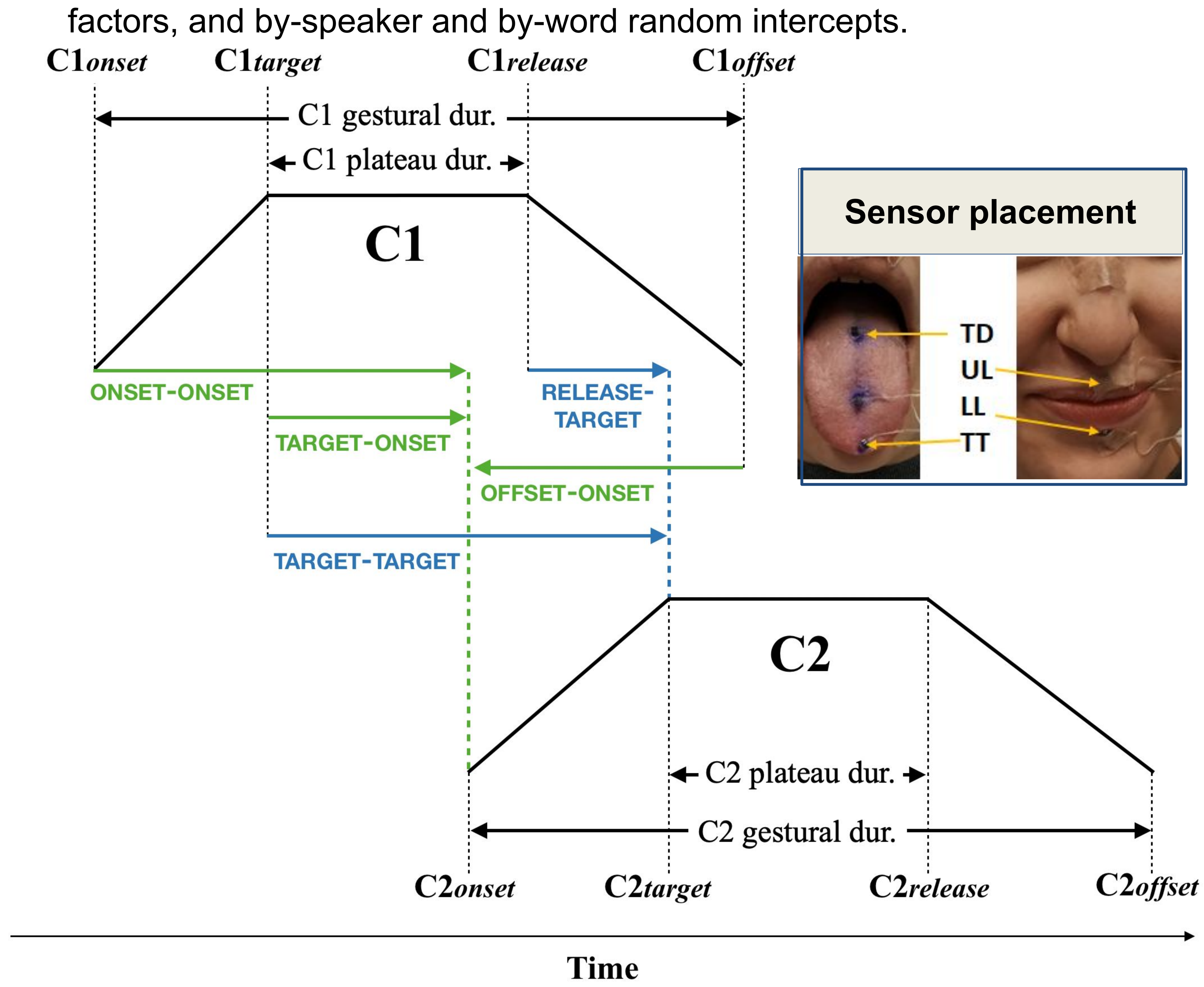

Figure 1: Gestural Landmarks & Intervals and Sensor Placement

Discussion

Summary of results: we found effects of morpheme boundary on 3/18 comparisons: 9 intervals X two measures {duration, variability}

- **Duration**: *C1 plateau, target-to-target*
  - but, *target-to-target* interval = *C1 plateau (sig)* + *release-to-target (nonsig)*, so likely driven by C1 plateau duration
- **RSD**: *target-to-onset* interval

Our interpretation: Lexical retrieval and/or motor program actuation exacts a temporal cost at morpheme boundaries (c.f. [2]);
Proposal: *articulation is gated at morpheme boundaries*

An exemplar-based proposal, following [6], doesn't work for our data
A word like *peck* occurs in different environments, including some (e.g. phrase final) that may lengthen the syllable. To the extent that such lengthening feeds back into an exemplar-based lexicon, it may condition a longer final consonant, /k/, than in a word like *inspect*, because the /k/ in *inspe[k]t* never occurs in a prosodically enhanced environment (e.g. adjacent to a phrase boundary). However, this account would predict an interaction with wordhood, as nonce words would not be subject to the same contextual enhancements that real words may undergo. **This prediction was not borne out in our data**.

The proposal derives effects of morpheme boundary on C1 plateau duration and target to onset variability as follows:

- **C1 plateau duration**: In our bi-morphemic sequences, we assume retrieval of the articulatory program for the second morpheme is initiated when the final gesture of the first morpheme achieves its target, facilitating a smooth transition to the second morpheme. Delays in lexical/motor program access materialize as longer *C1 plateau* duration. In mono-morphemic sequences, all gestures in the sequence belong to the same morpheme and may consequently be planned and actuated together. No additional gesture retrieval is required for a mono-morphemic sequence.
- **target-to-onset variability:** if the onset of the second morpheme is triggered when the final gesture of the first morpheme achieves its target, any **stochastic variability** in lexical/motor program access would manifest as temporal variability in C2 gestural onset.

[1] Bates, D., Maechler, M., Bolker, B., Walker, S. 2015. Fitting linear mixed-effects models using lme4. Journal of Statistical Software 67, 1-48. [2] Byrd, D., Saltzman, E. 2003. The elastic phrase: Modeling the dynamics of boundary-adjacent lengthening. J. Phon. 31, 149-180. [3] Cho, T. 2001. Effects of morpheme boundaries on intergestural timing: Evidence from Korean. Phonetica 58, 129-62. [4] Lee, J., Kim, S., Cho, T. 2019. Effects of morphological structure on intergestural timing in different prosodic-structural contexts in Korean. ICPhS. Melbourne. [5] R Core Team. 2017. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. [6] Seyfarth, S., Garellek, M., Gillingham, G., Ackerman, F., Malouf, R. 2018. Acoustic differences in morphologically-distinct homophones. Language, Cognition and Neuroscience 33, 32-49. [7] Tiede, M. 2005. MVIEW: Software for Visualization and Analysis of Concurrently Recorded Movement Data. New Haven, CT: Haskins Laboratories. [8] Goldstein, L. (2011). Back to the past tense in English. *Representing language: Essays in honor of Judith Aissen*, 69-88.